METHODS OF MANUFACTURING SEMICONDUCTOR DEVICES HAVING A RUTHENIUM LAYER USING VIA ATOMIC LAYER DEPOSITION AND ASSOCIATED APPARATUS AND DEVICES

Abstract of the Disclosure

Methods of fabricating a semiconductor device are provided in which a storage node contact plug is formed on a semiconductor substrate. A ruthenium seed layer is then formed via atomic layer deposition on the storage node contact plug, and a main ruthenium layer is formed on the ruthenium seed layer. The main ruthenium layer and the ruthenium seed layer are patterned to form a lower electrode, and a dielectric layer is formed on the lower electrode. Finally, an upper electrode is formed on the dielectric layer. The upper electrode may be formed by forming a second ruthenium seed layer using atomic layer deposition on the dielectric layer and forming a second main ruthenium layer on the second ruthenium seed layer. The main ruthenium layer and/or the second main ruthenium layer may be formed via chemical vapor deposition.